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ORIGINAL PAPER

Effect of iris registration on outcomes of FEMTOLASIK for myopia and myopic astigmatism

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Abstract
Purpose To compare the visual and refractive outcomes after FEMTOLASIK with and without iris registration.
Methods In this randomized, prospective, comparative, contralateral eye study, 118 eyes of 59 patients with myopia and myopic astigmatism underwent LASIK using the Femto LDV femtosecond laser (160 μm) and the MEL80 with or without iris registration. For each patient, iris registration FEMTOLASIK was performed on one eye and non-iris registration FEMTOLASIK was performed on the other eye, assigned at random. Patients were evaluated before and 12 months. Uncorrected visual acuity, best-corrected visual acuity, manifest refraction, contrast sensitivity, and higher-order aberrations (HOAs) were evaluated.
Results At 12 months, the mean UDVA was 0.002 ± 0.07 logMAR (20/19) in iris registration eyes and 0.00 ± 0.06 logMAR (20/24) in non-iris registration eyes ($P = 0.9$). 61% of iris registration eyes and 71.2% of non-iris registration eyes achieved a UDVA of 20/20 or better ($P = 0.31$); 98.3% of eyes with the iris registration FEMTOLASIK and 94.9% with the non-iris registration FEMTOLASIK were within ±0.50 D from emmetropia ($P = 0.71$). No statistically significant difference was found in postoperative contrast sensitivity between groups at 3, 6, 12, or 18 cycles/degree ($P > 0.05$). There was significant increase in total HOA root mean square in two groups. The mean *error magnitude* of surgically induced astigmatism 12 months postoperatively was −0.33 in iris registration eyes and −0.24 in the non-iris registration eyes ($P = 0.36$).
Conclusions FEMTOLASIK with and without iris registration provides similar results in myopic and myopic astigmatism patients.

Keywords FEMTOLASIK · Myopia · Iris registration · Outcomes

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Introduction

Eye movement and improper fixation can affect the outcome of laser refractive surgery, including in situ keratomileusis (LASIK), and cyclotorsional misalignment between the ablation beam and the eye can result in *postoperative* complaints because of residual undercorrection [1–5].

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Several studies have reported different degrees of cyclorotation ranging from 2° to 10° [6–8].

Misalignment associated with rotational eye movement could *not be detected* using pupil-based eye tracking systems.

Iris registration technology had been introduced to reduce or eliminate the adverse effect of minor eye movement due to cyclotorsion during LASIK.

In the iris registration process, an iris image is taken preoperatively. This image is matched with an iris image taken after creation, but not lifting, of the flap (i.e., just before the ablation is started). In this way, LASIK surgery with iris registration system may give a more accurate ablation which *accounts* cyclorotation of the eye during laser ablation compared to during the measurement.

In this study, we report the outcomes of a randomized prospective, contralateral eye study comparing FEMTOLASIK with and without iris registration technology in patients undergoing surgery for myopia and myopic astigmatism.

Methods

In this prospective randomized fellow-*eye* controlled *study*, *132 eyes* of *66 patients* with *myopia* or *myopic astigmatism* were treated with two different softwares for FEMTOLASIK.

In total, *130 eyes* of *65 patients* with *myopia* or *myopic astigmatism* were included in the study. All *surgical operations* were performed by one surgeon at the Persian Eye Clinic Isfahan Iran between December 2011 and February 2012. The University of Isfahan Medical Science approved the study.

One eye of each patient was selected at random to undergo FEMTOLASIK with iris recognition software, and FEMTOLASIK without iris recognition software was performed on the fellow eye.

Exclusion criteria were a cornea thinner than 500 μm, significant asymmetry on topography (the criteria for corneal irregularity were: increase in curvature greater than 47 D with inferior–superior asymmetry lower than 1.5 D, apex displacement greater than 1.5 D, and inferior–superior asymmetry greater than or equal to 1.5 D), previous corneal or intraocular surgery, unstable refraction, keratoconus, clinically significant lens opacity, systemic or ocular diseases, glaucoma.

All Participants underwent complete ophthalmic examination including uncorrected and corrected distance visual acuity (UDVA and CDVA), cycloplegic refraction, applanation tonometry, anterior and posterior segment biomicroscopy, Orbscan IIz (Technolas Perfect Vision, Munich, Germany), and aberrometer testing (Zywave II, Technolas Perfect Vision, Munich, Germany). Contrast sensitivity was measured *with* the *CSV 1000* device (VectorVision) under mesopic conditions. For LASIK, Femto LDV femtosecond laser (Ziemer Ophthalmic Systems AG, Port, Switzerland) was used to create flaps with 8.7–9.00 mm diameter and 110 μm thickness. The hinge is located in the superior position with angle of *50°,* and the *side-cut angle* was *70°*.

After flap creation, patients were told to keep their eyes closed for 5 to 15 minutes, and after complete resolution of the opaque bubble layer preablation iris registration was attempted.

Excimer laser custom ablation was performed, and at the completion of the *LASIK procedure one drop* of 0.3% *ciprofloxacin* and betamethazone eye *drops* was instilled. Postoperatively, patients *received ciprofloxacin* 0.3% and betamethazone for 7 days.

Follow-up was at *1* day, 1 week, 1, 3, 6, and 12 months *postoperatively*.

UCVA, refractive stability, predictability, contrast sensitivity, aberrometry, loss of CDVA, surgically induced astigmatism, error of magnitude, correction ratio, and error of angle and adverse event profile were measured. Data were analyzed with the SPSS statistical software (version 21 SPSS). Paired Student's test, independent sample test, and Wilcoxon signed rank test were used for analysis. For all statistics, a P value of <0.05 was considered statistically significant.

Results

A total of 59 patients were treated by FEMTOLASIK with successful iris registration and completed 1-year follow-up. The mean age of the 29 men and 30 women was 28.35 years (range 18–50 years). The preoperative visual characteristics and demographics were similar between the two groups (Table 1).

Efficacy and stability

Table 2 shows the postoperative results after 12 months. There were no statistically significant differences between two groups the mean UDVA (logMAR) or the percentage of patients achieving a UDVA of 20/20 or better ($P = 0.13$) or of 20/15 or better ($P = 0.34$). All eyes achieved UDVA of 20/25 or better 12 months after surgery. Refraction stability was similar in the two groups (Fig. 1).

Predictability

Table 2 also shows the predictability at 12 months. There were no significant differences between groups in the percentage of eyes within ±0.25 D or ±0.50 D of emmetropia at 12 months ($P = 0.75$ and $P = 0.71$, respectively). Figure 2 shows the correlation between attempted and achieved spherical equivalent refractions for both groups at 12-month follow-up.

Safety s*hows* the number of *CDVA lines lost or gained*.

Figure 3 shows the number of *CDVA lines lost or gained* at 12 months in two groups. None of the eyes in iris registration group lost one or more lines of CDVA, eight maintained their BSCVA, while six eyes gained one line, and 45 eyes gained two to seven lines of CDVA. The mean gain at 12 months was six lines of UCVA and 2.2 lines of CDVA. None of the eyes in non-iris registration group lost any lines of CDVA, eight maintained their CDVA, 14 eyes gained one line, and other 37 eyes gained two to five lines of CDVA. The mean gain at 12 months was six lines of UCVA and 1.9 lines of UCVA. *Corrected distance visual acuity* (*CDVA*) was *no worse than 20/25* in *either eye*.

Contrast sensitivity

Pre- and 12 months postoperative contrast sensitivity log values for the two groups are shown in Fig. 4. Statistically significant differences were noted in

Table 1 Comparison of preoperative characteristics

Parameter	Iris registration eyes	Non-iris registration eyes	*P* value
CDVA			
Mean logMAR	0.047 ± 0.05	0.043 ± 0.053	0.77
Snellen equivalent	0.89 ± 0.12	0.9 ± 0.11	0.58
Sphere (D)	−2.5 ± 2.1 D (−7.5 to −0.25 D)	−2.5 ± 2.00 D (−7.75 to −0.25 D)	0.91
Cylinder (D)	−3.18 ± 1.5 D (−0.5 to −8.00 D)	−2.9 ± 1.4 D (−0.5 to −6.75 D)	0.43
Sphere equivalent	−4.1 ± 2.00 D (−9.00 to 0.88 D)	−4.03 ± 1.9 D (−0.75 to −8.25 D)	0.86
Pachymetry (mm)	535 ± 37.8 (502–653)	535 ± 40.4 (510–655)	1.000
5-mm pupil			
Higher-order RMS	0.26 ± 0.09	0.26 ± 0.11	0.5
Higher-order RMS without spherical aberration	0.25 ± 0.1	0.25 ± 0.12	0.49
Total HOAs	4.5 ± 1.6	4.46 ± 1.6	0.31
6-mm pupil			
Higher-order RMS	0.44 ± 0.18	0.41 ± 0.15	0.61
Higher-order RMS without spherical aberration	0.41 ± 0.16	0.38 ± 0.15	0.66
Total HOAs	6.5 ± 2.4	6.5 ± 2.2	0.46

CDVA corrected distance visual acuity and *AHOAs* higher-order aberrations

Table 2 Comparison of 12-month postoperative data

Parameter			Iris registration	Non-iris registration	P value
Predictability	SE refraction (D)		-0.08+/-0.36	-0.03+/-0.46	o.49
	Within +/-0.25 D n (%)		44(74.5%)	43(72.8%)	0.75
	Within +/-0.50 D n (%)		58(98.3%)	56(94.9%)	0.71
	Sphere (D)		0.19+/-0.4	0.24+/-0.46	0.49
	Cylinder		-0.55+/-0.44	-0.55+/-0.42	0.95
Efficacy	UDVA	Mean Log MAR	0.002+/-0.07	0.00+/-0.06	0.84
		Snellen equivalent	0.99+/-0.16	0.98+/-0.14	0.95
	20/15 or better, n (%)		11(18.6%)	9(15.25%)	0.34
	20/20 or better, n (%)		36(61%)	42(71.18%)	0.13
	CDVA 20/20 or better, n (%)		54(91.5%)	54(91.5%)	1.00
Higher order RMS (5 mm)			0.33+/-0.15	0.31+/-0.11	0.97
Higher order RMS without spherical			0.32+/-0.02	0.3+/-0.11	0.94
aberration (5 mm)					
Total HOAs (5 mm)			0.92+/-0.56	0.82+/-0.45	0.81
Higher order RMS (6 mm)			0.59+/-0.22	0.57+/-0.2	0.85
Higher order RMS without spherical aberration (6 mm)			0.56+/-0.22	0.54+/-0.2	0.65
Total HOAs (6 mm)			1.5+/-0.84	1.45+/-0.64	0.73

SE sphere equivalent, *UDVA* uncorrected distance visual acuity, *CDVA* corrected distance visual acuity

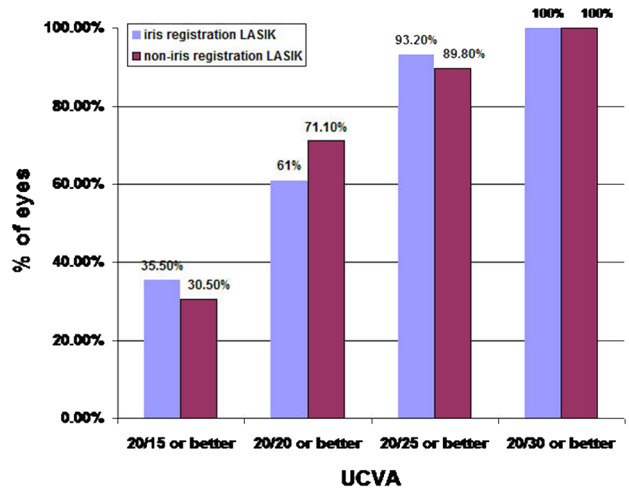

Fig. 1 Percentage of eyes achieving uncorrected distance visual acuity at 12 months (LASIK = laser in situ keratomileusis; UDVA uncorrected distance visual

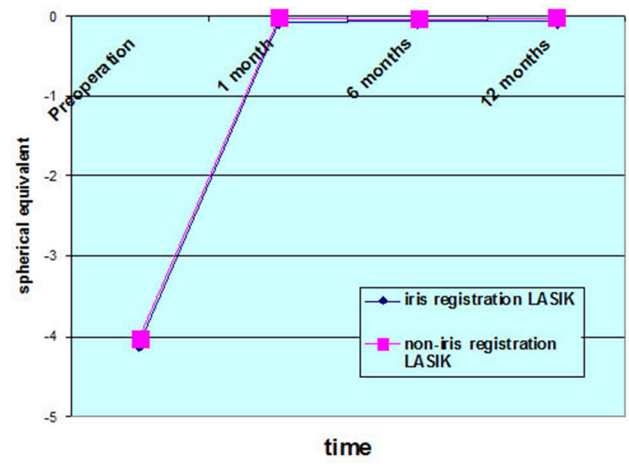

Fig. 2 Stability of refraction over time (LASIK=laser in situ keratomileusis; SE = spherical Equivalent)

either group between the preoperative and postoperative contrast sensitivities at any cycle. No statistically significant difference was noted between groups in contrast sensitivity at four spatial frequencies (3 cpd, 6 cpd, 12 cpd, or 18 cpd) ($P > 0.05$).

Wavefront analysis and higher-order aberrations

Table 2 shows the preoperative and 12-month postoperative Zernike RMS in wavefront diameter 5 and 6 mm for two groups. The difference between the preoperative and postoperative data was statistically significant in either group at any RMS. Figure 5 compares the absolute changes in higher-order RMS and higher order without Z400 in wavefront diameter 5 and 6 mm, between the iris registration eyes and the non-iris registration eyes. The difference between the two groups in the change in wavefront from baseline was not statistically significant ($P > 0.05$).

Residual and surgical induced astigmatism

The mean residual astigmatism at 12 months in the iris registration FEMTOLASIK eyes and non-iris registration FEMTOLASIK eyes was 0.55 ± 0.44 and 0.55 ± 0.42 D, respectively ($P = 0.95$) (Table 2). By vector analysis, the mean surgically induced astigmatism in the iris registration group and the non-iris registration group was 2.5 ± 1.16 and 2.3 ± 1.1, respectively ($P = 0.49$) (Tables 3, 4). The percentage of attempted cylinder correction achieved in iris registration FEMTOLASIK eyes and non-iris registration FEMTOLASIK eyes was 44.7 and 47.3%, respectively ($P = 0.766$). In the iris registration

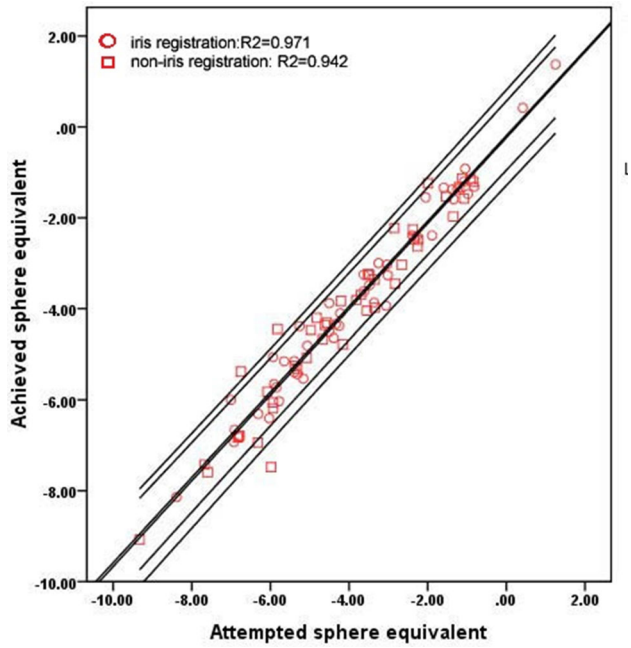

Fig. 3 Attempted versus achieved spherical equivalent refraction at 12 months in eyes that underwent FEMTOLASIK with and without iris registration

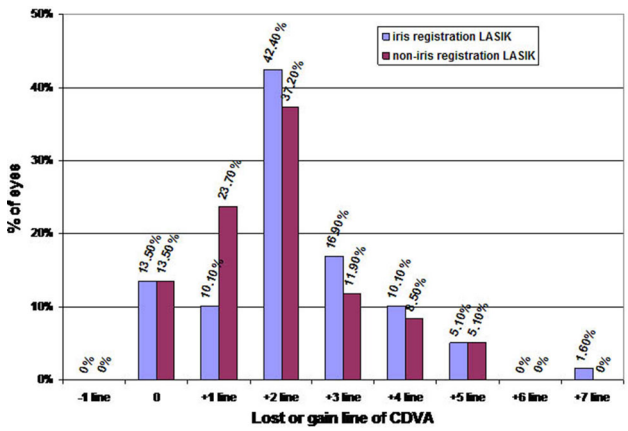

Fig. 4 **a** 12-month safety by CDVA (CDVA = corrected distance visual acuity; LASIK=laser in situ keratomileusis)

group, 28.81% of eyes had a clockwise cylinder axis shift (error of angle <0), 40.67% of eyes had a counterclockwise shift (error of angle >0), and 94.9% of eyes had an axis shift of <10°. In the non-iris registration group, these values were 35.5, 42.37, and 93.22%, respectively.

Angle between the targeted astigmatism and post-operative astigmatism is angle of correction. In this study, the targeted cylinder axis was assumed to be the same as the preoperative cylinder. *There was no significant* difference between the iris registration group and the non-iris registration group in the percent of eyes achieving an absolute difference in axis preoperatively to postoperatively of 0°–20° (Z test, $P = 0.48$), 21°–40° (Z test, $P = 0.51$), 41°–90° (Z test, $P = 0.7$), and 91°–180° (Z test, $P = 0.1$). Angle of correction is a measure of the final astigmatic result, and it is not as useful as the angle of error in determining and comparing the success of astigmatic surgery.

Discussion

In our study, FEMTOLASIK with iris registration and FEMTOLASIK without iris registration were both

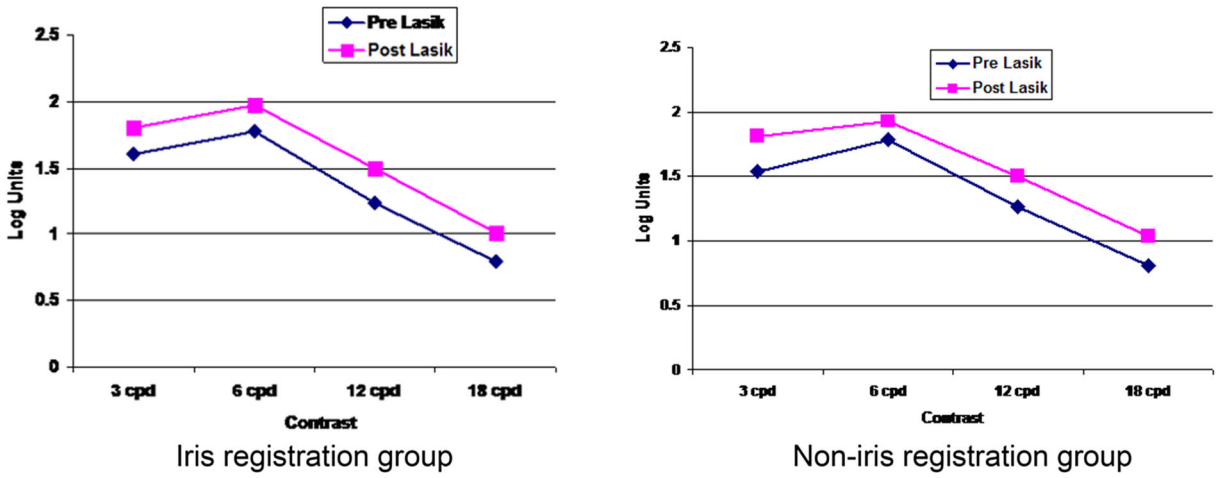

Fig. 5 Mean log contrast sensitivity values over time in the iris registrated group and non-iris registrated group (cpd = cycles per degree, LASIK=laser in situ keratomileusis

Table 3 Postoperative astigmatism results in eyes that underwent FEMTOLASIK with and without iris registration after 12 months

Parameter	Iris registration eyes	Non-iris registration eyes	*P* value*
SIA (D)	2.5 ± 1.1 (0.22–5.1)	2.3 ± 1.1 (0.22–5.3)	0.58
EM (D)	−0.33 ± 0.52 (−1.6 to 0.74)	−0.24 ± 0.5 (−1.8 t 0 0.99)	0.36
CR	0.88 ± 0.19 (0.48–1.5)	0.85 ± 0.36 (−1.8 to 1.8)	0.58
EA (°)	4.01 ± 9.8 (0.00–59.3)	4.2 ± 8.3 (−1.13 to 60.7)	0.88

$P < 0.05$

SIA surgically induced astigmatism, *EM* error of magnitude (EM < 0: overcorrection, EM > 0: undercorrection), *CR* correction ratio; (CR < 1: undercorrection, CR > 1: overcorrection), *EA* error of angle; (EA < 0: clockwise shift of axis, EA > 0: counterclockwise shift of axis)

effective at treating myopia with or without astigmatism. Both techniques demonstrated predictable and stable results and also significant improvement in UCVA at 12 months. Both techniques demonstrated high safety profiles by no eyes losing lines of CDVA, contrast sensitivity loss, or incidents of complications (Fig. 6).

To the best of our knowledge, only one study [9] has been specifically designed to compare the visual and refractive results of LASIK with and without iris registration in the same patient (with astigmatism ≤−3 D using microkeratome, unlike our study). In a contralateral study comparing 52 eyes treated with LASIK using iris registration and 52 eyes with LASIK without iris registration, Wu et al. [9] found better visual outcomes and contrast sensitivity and *less induction* of *HOAs* after LASIK with iris registration 3 months after the surgery. However, they only treated spherical equivalent of manifest refraction less than −8.00 D and manifest astigmatism −3.00 D or less and they do not indicate the predictability and safety of study. Our study reports outcomes at 12 months and suggests that iris registration does not significantly improve visual outcomes in comparison with a non-iris *registration platform.* In fact, there was a higher percentage of patients achieving 20/20 or better UCVA in the non-iris registration FEMTOLASIK eye (61 vs. 71.1%). In addition, our study shows that there was no statistically significant difference with the use of iris registration in inducing less higher-order aberration or in achieving more accurate cylinder correction. The difference in our findings from that previously reported [9] may be due to a longer follow-up period in our study.

Table 4 Postoperative astigmatism results in eyes (>1.00 D preoperative astigmatism) that underwent FEMTOLASIK with and without iris registration after 12 months (1.00 D preoperative astigmatism)

Parameter	Iris registration eyes ($n = 55$)	Non-iris registration eyes ($n = 51$)	P value*
SIA (D)	2.6 ± 1.07 (0.76 to 5.1)	2.6 ± 0.95 (0.5–1.41)	0.99
EM (D)	−0.35 ± 0.53 (−1.6 to 0.74)	−0.29 ± 0.53 (−1.8 to 0.99)	0.57
CR	0.88 ± 0.16 (0.5–1.41)	0.85 ± 0.36 (−1.28 to 1.8)	0.57
EA (°)	2.2 ± 2.5 (0.0–10.8)	3.2 ± 3.1 (−1.13 to 15)	0.08

$P < 0.05$

SIA surgically induced astigmatism, *EM* error of magnitude (EM < 0: overcorrection, EM > 0: undercorrection), *CR* correction ratio (CR < 1: undercorrection, CR > 1: overcorrection), *EA* error of angle (EA < 0: clockwise shift of axis, EA > 0: counterclockwise shift of axis)

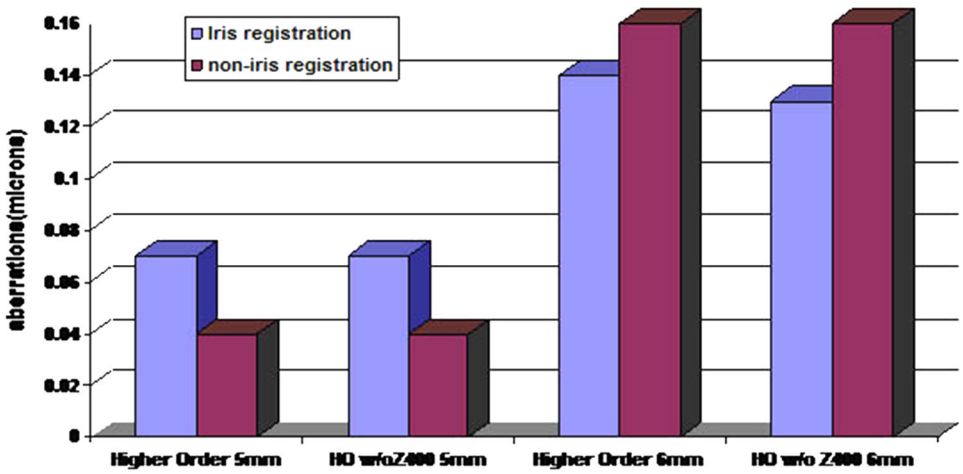

Fig. 6 Absolute changes in higher order aberrations in each group at 12 months(LASIK=laser in situ keratomileusis,; RMS Z root mean square)

Wu et al. [9] reported an increase in HOAs of approximately 50% 3 months after iris recognition LASIK and 57% after wavefront-guided LASIK.

In our study, increase in HOAs is approximately 34 and 39% in eyes with iris *registration FEMTOLASIK and* non-iris registration FEMTOLASIK, respectively.

There are several published reports of LASIK with iris registration. Ghosh et al. [10] compared the visual and refractive outcomes of 100 myopic eyes treated with wavefront-guided LASIK using iris registration system to *98 myopiceyes without iris registration system.* They found that in the iris registration group, a higher percentage of eyes (92%) than in the control group (85.7%) were within ±0.5 D range in SE and statistically significant difference in the amount of astigmatic correction was seen between the two groups. The index of success was 98.0% in the iris registration group and 81.6% in the control group ($P = 0.03$) after 3 months.

In our study, 98.3% of eyes with iris registration FEMTOLASIK and 94.9% of eyes without iris registration FEMTOLASIK were within ±0.5 D range in SE, but difference was not statistically significant ($P = 0.7$) and the index of success was 78.0% in the iris recognition group and 79% in the control group ($P = 0.8$) after 12 months.

Table 5 Previous studies of LASIK outcomes with and without iris registration

Authors	Sudipta Ghosh [10]	Mohirfar et al. [11]	Wu et al. [9]	Khalifa et al. [12]
Procedure	Wavefront-guided LASIK (iris registration and non-iris registration)	LASIK using the VISX STAR S4 CustomVue (iris registration and non-iris registration)	LASIK surgery with the MEL80 excimer laser system	Conventional LASIK vs WG-LASIK vs WG-LASIK with iris registration
No. of eyes	100 eyes IR+ 98 eyes IR−	121 eyes IR+ 118 eyes IR−	52 eyes IR+ 52 eyes IR− Same patient.	Conventional LASIK (20 eyes) WG-LASIK (20 eyes) WG-LASIK with iris registration (20 eyes)
Mean follow-up (mos)	3 months	6 months	3 months	3 months
Postoperative UCVA (%) > 20/20	90% IR+ 76.5% IR−	79% IR+ 78% IR−	96.2% 92.3%	Conventional LASIK 65% WG-LASIK 75% WG-LASIK +IR 90%
Loss of CDVA (%) One line, >2 Lines	2% in IR+ 4% in IR− More than one line	One line 16% IR+ 16% IR− >2 line O% IR+ O% IR−	Na Na	One line Conventional LASIK 15% WG-LASIK 10% WG-LASIK +IR 0%. >2 line Conventional LASIK 0% WG-LASIK 0% WG-LASIK +IR 0%
% of eyes within desired refraction ±0.50 D,	92% in IR+ 85.7% in IR−	92% IR+ 90% IR−	Na Na	Conventional LASIK 65% WG-LASIK 70% WG-LASIK +IR 80%
Complications	None		Na	Na

Authors	Prakash et al. [13]	Zhang et al. [14]	Current study
Procedure	WG-LASIK	WG-LASIK with iris registration versus conventional LASIK	FEMTOLASIK with and without iris registration
No. of eyes	148 eyes IR− 136 eyes IR+ static 133 eyes IR+ dynamic	WG-LASIK with IR (436 eyes) conventional LASIK (416 eyes)	FEMTOLASIK with iris registration (59 eyes) FEMTOLASIK without iris registration (59 eyes)
Mean follow-up (mos)	6 months	12 months	12 months
Postoperative UDVA (%) > 20/20	70.9% IR− 80.1% IR+ static 87.2% IR+ dynamic	94.4% WG-LASIK IR+ 88.2% LASIK	LASIK with IR (61%) LASIK without IR (71.1%)
Loss of CDVA (%) one line, >2 lines	0% 0% 0%	1 line 0% WG-LASIK IR+ 8.9% LASIK	LASIK with IR 0% LASIK without IR 0%

Table 5 continued

Authors	Prakash et al. [13]	Zhang et al. [14]	Current study
% of eyes within desired refraction ±0.50 D,	68.2% IR− 83.1% IR+ static 93.9% IR+ dynamic	92.6% WG-LASIK IR+ 86.3%	LASIK with IR 98.30% LASIK without IR 94.9%
Complications		None	None

Previous studies of LASIK with iris registration show varied results [9–14] and are summarized in Table 5.

Moshirfar et al. [11] retrospectively evaluated the results of 239 myopic eyes, with or without astigmatism treated with LASIK (121 eyes with iris registration and 118 eyes without registration) using the VISX STAR S4 CustomVue and suggested that wavefront-guided LASIK with the VISX CustomVue platform, independent of iris registration status, is safe, effective, and predictable and did not find any statistically significant evidence supporting the achievement of better visual acuity or the lesser induction of higher-order aberration with the use of iris registration technology in comparison with non-iris registration.

Our findings are in agreement with this study. In our study, in iris registration FEMTOLASIK group, 10.2% eyes gained one line and 76.4% gained two or more lines while 23.8% eyes gained one line and 62.8% gained two or more lines in non-iris registration FEMTOLASIK group 1 year after surgery. No eyes in the each FEMTOLASIK group lost any lines of CDVA.

Mohifar et al. [11] reported that in iris registration group 27% eyes gained one line of CDVA and in non-iris registration group 22% eyes gained one line of CDVA, and one eye gained two lines of CDVA; 0.19% eyes in the iris registration group and 24% eyes in non-iris registration group lost one line of CDVA.

Prakash et al. [13], comparing 148 eyes receiving LASIK without iris registration, 136 eyes receiving LASIK with static iris registration, and 133 eyes receiving LASIK with dynamic iris registration, found in cases of myopia with astigmatism higher than 1.0 D the outcomes will be better when iris registration with dynamic rotational eye tracking is used than when static iris registration or no iris registration is used.

Zhang and associates [14] compared conventional LASIK and wavefront-guided LASIK using iris registration technology. In their study, a significant better visual performance was got in wavefront-guided LASIK group compared with conventional LASIK group 1 year after surgery, and they reported that in eyes *with high-magnitude RMSh*, the wavefront-guided LASIK is suitable.

Patients' *overall self-assessment* of visual satisfaction is poorer in the non-iris registration FEMTOLASIK eyes at 12 months, but not significant ($P = 0.8$). Residual lower-order aberrations *may be consistent* with many of these symptoms in the FEMTOLASIK without iris registration eyes.

Although there was no difference ($P = 0.49$) in mean spherical equivalent at 12 months between FEMTOLASIK with and without iris registration treated eyes, in this study iris registration technology did not prove to be as beneficial as other studies. Several reasons may have been responsible for that: Iris registration technology allows pupil tracking throughout the procedure, but changes throughout the procedure torsional movements or centroid shift changes are not accounted. Other reasons may be a fact that in this study the iris registration was done prior to creating the IntraLase flap and lifting the flap often requires significant manipulation of the globe and a different resting position upon completion. Finally, iris registration algorithms compensate rotation and translation automatically, and in cases where iris capture could not be obtained, the surgeon compensate manually.

Despite the lack of substantial differences between iris registration and non-iris registration in visual outcomes or higher-order aberrations, advantages of iris registration over other methods of alignment include: Iris registration relies on matching reference

points in the natural iris pattern, is automated, noninvasive technology, and does not depend on surgeon subjectivity, and compared to other methods patient discomfort is minimal.

This study demonstrated that the visual and refractive outcomes at 1 year following treatment of myopia and myopic astigmatism with FEMTOLASIK independent of iris registration status were very satisfactory and use of iris registration does not lead to statistically significant improvements in visual outcomes or induction of fewer higher-order aberrations.

More studies with longer follow-up are needed to determine if there is a true difference in the efficacy of the iris registration algorithm for FEMTOLASIK.

Compliance with ethical standards

Conflict of interest Authors do not have any financial interest in any products mentioned in this article.

Human and animal rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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